Friendly fuel ~ easy & plenty

A cheap way of generating hydrogen may become a practical solution to the energy problem, says **S Ananthanarayanan**

Hemalala Karunadasa

Christopher Chang

Jeffrey Long

HEMALALA Karunadasa, Christopher Chang and Jeffrey Long of the University of California and the Lawrence Berkley National Laboratory at Berkley, California, report in the journal *Nature* that they have developed an effective, synthetic catalyst that can help generate large volumes of hydrogen gas from water, including sea water. Getting hydrogen economically would be a source of energy without carbon dioxide emission and this may be just what the world is looking for.

Half solutions

There are many instances of false "clean" energy. Airports and railway stations, for instance, run battery-operated transport and announce that this is "environment friendly". But the lead-acid batteries they use, apart from being expensive, need to be charged, and this takes costly electricity from conventional power plants. While the generation of electricity itself is only partially efficient, the conversion to battery power and then to run transport is wasteful — and it would have been greatly more environment-friendly to have directly used a diesel or petrol engine.

Truly environment-friendly energy use would be the kind where the process is not finally dependant on conventional energy production, which is usually fossil fuel-based and harmful to the environment.

Hydrogen as fuel

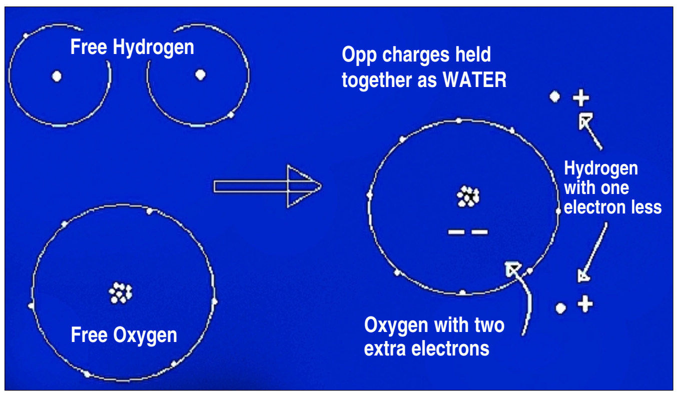
There are different ways of using hydrogen as fuel. In chemical terms, the hydrogen atom consists of one heavy, positively charged particle, the proton, as its nucleus and one light, negatively charged particle, the electron, in orbit around the nucleus. For best stability, hydrogen tends to give up its lone electron to another atom, which could gain stability by having one more electron. The oxygen atom is one such, which can do with two more electrons. Two hydrogen atoms thus combine with one oxygen atom to yield a stable compound, H_2O, or water.

A stable condition is usually a low energy condition, just like a pencil on its side is more stable and has less energy than a pencil standing on its point. Hence, hydrogen has less energy when it is in combination, as water, or many other chemical pairings. But when, with the use of energy, hydrogen is plucked out of this low energy condition, the free hydrogen has more *energy*, usually the energy used to set it free from combination.

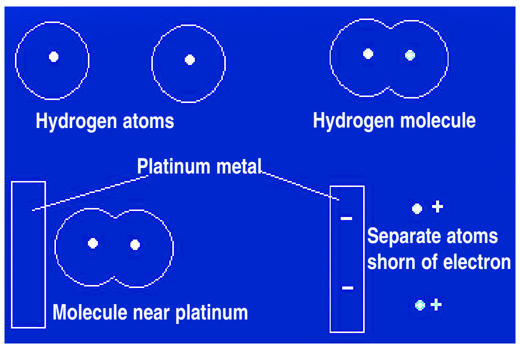
This free hydrogen can then be stored and the energy can be tapped, either as heat by burning in oxygen to produce water (vapour), or in other chemical reactions, or even in an arrangement that creates electricity directly.

This last arrangement is called a fuel cell. Most of us know that if an electric current is passed though water, the water splits into hydrogen and oxygen. As electric current is a flow of electrons, the electric force is able to pull apart the hydrogen atoms that have lost an electron to oxygen, and recreate free, gaseous hydrogen by supplying the missing electron.

In a reverse way, if hydrogen is pumped into the medium between two metallic surfaces, the hydrogen begins to combine with oxygen or other substances in the medium and create an electric charge on the metallic surfaces. When the surfaces are connected together, a current flows between them, which is nothing but electricity generated by the supply and consumption of hydrogen.



The other way of using hydrogen, of course, is simply to burn it in oxygen, which creates heat to run turbines, etc, to create electricity, just like burning coal or natural gas. The difference is that the product of burning hydrogen is only water vapour and the environment is not polluted with carbon dioxide. The oxygen used up, also, is equal to the oxygen that must have been released along with the production of the hydrogen, which even things up.



Producing hydrogen

The problem is, how to get the hydrogen? The usual way is by passing electricity through water. In this process, the cost, in terms of pollution in producing the electricity used to generate hydrogen, is much more than the clean energy that can come from the hydrogen. There are cheaper methods to produce hydrogen, like using steam and coke or by chemical reactions, but finally the arithmetic is the same, that we spend more than we gain.

An answer seems to lie in the method used by natural systems. There are some micro-organisms that need hydrogen to power their metabolism. These organisms do not have sources of heat or electricity to create hydrogen in the usual way. They employ chemical intermediaries, called catalysts, which can lessen the load, or increase the yield and enable processes that produce hydrogen in difficult conditions.

These catalysts, called hydrogenase enzymes, are organic substances that contain metals like nickel or iron, and have been observed in algae and bacteria. They extract hydrogen from sulphates or other chemical sources. And they speed up the reaction where the hydrogen molecule gives up two electrons and splits into two positively charge atoms. The normal form of hydrogen is the molecule where two atoms share their single electrons, to mimic a more stable condition of having two electrons each. But in the presence of metals like platinum, the molecule can give up the electrons and split into two positively charged atoms. And the reaction is reversible, which means the two positively charged atoms can join and form a hydrogen molecule if they meet a source of electrons.

It is this separation of the hydrogen atom from a state of combination to the free state and recombination that enables a hydrogen atom to get free from compounds and then to meet another hydrogen atom and start life afresh as a hydrogen molecule. The new and old conditions are freely reversible and creation of hydrogen like this needs a mechanism to speedily whisk away the new hydrogen. One of the methods being the use of electricity and also special metal surfaces, like platinum, to assist. But then, the cost of the electricity and the special metals can lead to the hydrogen created being too expensive!

Biological methods use light energy or ambient heat to set hydrogen free, and mimicking the processes is an attractive quest. But the trouble with most biological processes and the catalysts to make them efficient is that the substances involved are unstable outside bacterial or cellular confines and are not suitable for largescale hydrogen generation.

Promising discovery

The development reported by Professor Jeffrey Long and others is of a synthetic, complex molecule that combines a metal-oxygen bond to be effective in setting hydrogen atoms free but avoiding the pitfalls. There are other metal-sulphur complexes that can generate hydrogen ions in organic solvents. There are also metal complexes that work well but they also need organic acids or additives or solvents. Precious metals, too, show high efficacy but their high cost rules them out.

The present development is a simple molybdenum-oxygen complex that catalyses hydrogen generation from ordinary water with high efficiency — a prototype of an effective and robust molecular agent. The catalyst appears to act by the oxygen component forming a bond to take away two H^+ atoms from two water molecules and later releases the two H^+ atoms as a H_2 molecule, to be harvested.

The discovery is promising and may lead to processes that could generate hydrogen from water with the help of sunlight — of great relevance to sustainable energy cycles.

The writer can be contacted at simplescience@gmail.com

Shrinking size for superiority

Metamaterials find their way to wireless handsets and routers. **Saswato R Das** reports

THE quest to build more powerful, multiband mobile handsets has gotten a boost from a relatively new class of materials. These so-called metamaterials are specifically engineered to have properties that do not occur naturally, such as the ability to bend light the wrong way. For manufacturers of mobile devices, recent advances in metamaterials promise a way to shrink size while still retaining multiband functionality.

LG Electronics' new Chocolate BL40 mobile handset, from its high-end Black Label series, incorporates a metamaterial antenna made by San Diego-based Rayspan, a start-up that is pioneering the commercialisation of metamaterials. (Among Rayspan's backers are Khosla Ventures and Sequioa Capital, two venture capital firms with an impressive track record of technology foresight.) LG Electronics is the first company to use metamaterials in mobile handsets. Woo Paik, its president and chief technology officer, said metamaterials allowed LG to "achieve the dramatically sleek, slim dimensions of the new LG Chocolate and unsurpassed radio frequency capabilities". The LG BL40 is 10.9 mm thick, features a four-inch 21:9 display, a 5-megapixel camera and has got good reviews.

Maha Achour, Rayspan's chief technical officer, said that the antenna used in the LG handset was a few millimetres long, as thin as paper and simplified the integration of both GPS and Bluetooth protocols. The same array was shared by the cellular and Wi-Fi radios within the handset.

Since 2008, internal metamaterial antennas made by Rayspan have been incorporated into RangeMax wireless routers made by Netgear, allowing the routers to reduce radio frequency interference and enable superior range. Netgear was the first company to adopt metamaterials technology. The metamaterial antennas have proved to be robust. They are inexpensive as well, says Achour, and are fabricated directly on the printed circuit boards of the routers, on which the electronic circuit is laid out. "There are over 20 million metamaterial antennas in the market," he says. "None of them require any customer support."

Metamaterials have become very popular in the last decade, partly because they can be used for novel applications such as invisibility cloaks. The major impetus came from the work of Sir John Pendry of Imperial College, London. In 2000, he wrote about creating a perfect lens with a metamaterial. He also theorised that the magnetic properties of a material could be changed by manipulating its physical structure. In nature, materials are either magnetic or not – they can either be magnetised (like iron) or not (like wood). Pendry wondered whether one could create a material that was magnetic by proper design. He imagined minuscule copper loops embedded on fiber glass. While copper isn't magnetic, such a design should be magnetic, he hypothesised.

Experimentalists seized upon the idea. Much research has been done since. The basic trick for metamaterials is that their structures contain features that are considerably smaller than the wavelength of electromagnetic radiation at which they are supposed to do their work. As predicted by Pendry, electromagnetic wave propagation through metamaterials is fundamentally altered from that of conventional materials.

The writer is based in New York and can be contacted at saswatodas@gmail.com

Handling chemicals with care

Tapan Kumar Maitra explains the advantages and drawbacks of the various methods of applying pesticides and some of the modern procedures that help mitigate risk

SPRAYING is a widely used method of applying pesticides in the form of solutions, emulsions or suspensions. Special equipment-sprayers are also extensively used. It is a universal method of applying pesticides and has substantial advantages over other methods; with a very low consumption of the active ingredient per unit of area, it is possible to ensure uniform distribution and good covering of the surfaces being treated. When wetting agents and adhesives are added to the working solutions a high rate of retention of the pesticide on the treated object is ensured. Spraying depends, to a smaller extent, on the meteorological conditions. In addition, combined pesticide compositions can be used for spraying, which is virtually impossible in dusting.

The shortcomings of spraying include the complications involved in preparing the working compositions and in observing the preset rate of use of the liquid and the dose of the pesticide, and also spoiling of the apparatus as a result of corrosion and the use of a large amount of liquid, which makes treatment more costly. For example, in the surface treatment of orchards and woods, liquid is used at a rate of 2,000 litres per hectare and when treating field crops 400 to 500 litres.

Of special importance in aerial spraying is the homogeneity of the drops. Achievement or the optimal size of the drops is needed for reducing toxicant loss because of their drift under the action of eddy air currents and evaporation. Four main classes of drop dispersion are distinguished in aerial spraying. In aerial chemical treatment, droplets of aerosol size and small drops lend themselves to drift and evaporation, which is associated with the low initial velocity of their falling and the very small distance they travel during their "lifetime".

According to G Hartley a droplet of a one per cent aqueous solution with an initial size of 50 mm already in a few seconds transforms into a more or less dry particle with a diameter of about 11 mm. Such dry particles are easily carried off by an air current and rarely settle on plants. Many countries these days use ultrasmall volume spraying with undiluted emulsifiable concentrates. In comparison with small-volume spraying, ultrasmall-volume spraying increases the productivity of aerial treatment and cuts cost.

The concentrates used for such spraying must have fluidity at room temperature, a density of at least one g/cm^3, low toxicity to mammals and high biological activity. They must also be harmless to plants and leave no persistent residues.

In connection with the use of ultrasmall-volume spraying, our notions regarding the effective size of pesticide drops have changed. It was found that an insecticide in the form of fine drops is considerably more toxic than in large ones. The American experience of ultrasmall-volume aerial spraying of large territories populated by blood-sucking flies from a height of several hundreds of metres deserves attention. Ultrasmall-volume spraying is superior to other kinds of treatment in its effectiveness, which is explained by the more prolonged action of the technical insecticide in comparison with diluted emulsions.

The effectiveness of aerial spraying depends on the homogeneity of the drops.

Moreover, in case of such spraying no preliminary preparation of the solutions and emulsions is needed, which diminishes the possibility of contact with the toxicants. At present, special insecticides for ultrasmall-volume treatment are being prepared and tested. Among them are ritsifon (a 30 per cent solution of neutral trichlorfon), malathion (a 40 per cent solution of malathion in ethyl cellosolv) and dilor (a 15 per cent solution in nephitocide oil and 70 per cent formothion).

In surface treatments, three kinds of spraying are common — large, small and ultrasmall-volume.

Large-volume spraying is used when the pesticide is phytocidal in increased concentrations, exhibits only contact action, requires abundant wetting of the plants and is highly toxic to humans. It is also used on small areas and for treating individual trees. Liquids are widely used when working with fungicides.

Dusting is the application of dust formulations to plant surfaces or insects with the aid of a special apparatus, its main advantage being its simplicity. Special compositions do not have to be prepared directly before work because ready dusts are available. In addition, pesticides in the form of a dust cover dense cereal crops very well.

Fumigation is one of the most widespread ways of controlling pests of reserve supplies in storage and transportation, pests and diseases in sheltered ground, pests and diseases of planting stock as well as valuable citrus crops and tea. It is widely used to control pests and rodents. It is a very effective method because poisonous vapour or gases together with air penetrate very well into various porous materials, cracks and the most minute openings in which harmful organisms nest. With good sealing of the object, the observation of proper fumigation techniques and the required exposure a 100 per cent decontamination effect can be obtained.

The effectiveness of fumigation and the technique followed in performing it depend on the properties of fumigants and on the state of aggregation (liquid, gas or solid). The most important properties of fumigants are volatility, rate of evaporation, diffusion in air, liability to explode or ignite, degree of sorption by various objects, action on metals and other materials, toxicity and degasability.

Volatility is characterised by the maximum amount of vaporous fumigant contained at a given temperature and pressure in unit volume of air. It is expressed in mg/litre or in g/m^3 of air and grows with an increasing air (fumigant) temperature. The rate of evaporation of a fumigant is determined by the volume of the vapour evaporating from an area of one cm^2 in a minute or so. It increases with elevation of the air temperature and a growth in the open area. To rapidly obtain the required fumigant concentration in the premises being gassed — lethal to the harmful organisms — the fumigant or the room itself is heated, while liquid fumigants are poured into flat pans or sackcloth and hung up in the premises to increase the evaporating surface.

The penetration of fumigant vapour into the body of objects being decontaminated can be accelerated by raising the temperature and by using the vacuum chamber and other technical contrivances.

The writer is Associate Professor and Head, Department of Botany, Ananda Mohan College, Kolkata

Save a child

Retinoblastoma in developing countries is a common finding, but this cancer is very treatable

RETINOBLASTOMA or Rb is a rapidly developing cancer that begins in the cells of the retina, the light detecting tissue of the eye. In the developed world, Rb has one of the best cure rates of all childhood cancers (95-98 per cent), with more than nine out of every 10 sufferers surviving into adulthood. It is a very treatable cancer. However, Rb presence with advanced disease in developing countries and eye enlargement is a common finding.

There are two forms of the disease — a genetic, heritable form and a non-genetic, non-heritable form. Approximately 55 per cent of children with Rb have the non-genetic form. If there is no history of the disease within the family, the disease is labelled "sporadic", but this does not necessarily indicate that it is the non-genetic form.

The most common and obvious sign of Rb is an abnormal appearance of the pupil, *leukocoria*. Other less common and less specific signs and symptoms are: deterioration of vision, a red and irritated eye, faltering growth or delayed development. Some children with Rb can develop a squint, commonly referred to as "cross-eyed" or "wall-eyed" (*strabismus*). Retinoblastoma is rare and affects approximately one in 15,000 live births. Most children are diagnosed before the age of five years old.

With the "Fourth World Retinoblastoma Awareness Week" concluding on 15 May, here are some facts: The most common malignant eye cancer in children, Rb is curable if diagnosed early; take a flash photograph of your child and check to see if there is a white shiny glint reflecting back from the child's eye – that's a symptom of Rb; paediatricians should check the eyes for abnormal reflex and squint during a child's visits for immunisation and health check-up; general ophthalmologists should dilate the child's eyes and look at the retina; children with suspected Rb should be referred to an eye hospital for appropriate management; treatment can save a child's life, prevent removal of the eyes and save its vision. Chemotherapy, radiation therapy and local therapy can successfully treat a child and save its life.